#21/Appeal Brief
OK ON 3/18/03

Attorney's Docket No. 42390P5832

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application for:

Donald S. Gardner, et al.

Serial No. 09/253,306

Filed: February 19, 1999

For: **INTERCONNECTION ALLOY FOR INTEGRATED CIRCUITS**

Patent Office: Tran, T.

Art Unit: 2811

APPEAL BRIEF

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

Applicants (hereinafter "Appellants") submit in triplicate, the following Appeal Brief pursuant to 37 C.F.R. § 1.192 for consideration by the Board of Patent Appeals and Interferences. Appellants also submit herewith a check in the amount of $320.00 to cover the cost of filing the opening brief as required by 37 C.F.R. § 1.17(c). Please charge any additional amount due or credit any overpayment to deposit Account No. 02-2666.

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I. REAL PARTY IN INTEREST

Donald S. Gardner and Thomas N. Marieb, the parties named in the caption, assigned their rights to the invention disclosed in the subject application through an Assignment recorded on February 19, 1999 at reel and frame 9785/0137 to Intel Corporation, 2200 Mission College Blvd., Santa Clara, California 95052. Therefore, Intel Corporation is the real party in interest.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in this Appeal.

III. STATUS OF CLAIMS

Claims 4-6, 9-11, 14-16 and 19-22 are pending in the application. The Patent Office has rejected claims 4-6, 9-11, 14-16 and 19-22. Appellants appeal the rejection of claims 4-6, 9-11, 14-16 and 19-22.

IV. STATUS OF AMENDMENTS

No amendments were filed subsequent to the final rejection.

V. SUMMARY

Embodiments provide an apparatus for an interconnect formed on a substrate. Application, page 7, lines 2-5. The interconnect is formed from an aluminum-copper-Group IV metal alloy. Application, page 7, lines 2-5. The interconnect may be formed as an aluminum-copper-titanium alloy (titanium is a Group IV metal) including one embodiment where the alloy is 0.5 atomic percent copper, 0.1 atomic percent titanium and the remainder is aluminum. Application, page 9, lines 3-6. This interconnect may be used as part of an interconnection stack to connect, for example, individual devices on a chip or signals to or from the chip. Application, page 8, lines 1-

2. One example of an interconnect stack is a Ti/TiN/Al-Cu-Group IV metal/Ti/TiN stack. Application, page 8, lines 10-11. This interconnect stack or system has an increased electromigration lifetime by at least a factor of two with minimal impact on resistivity when compared to prior art interconnections. Application, page 7, lines 8-11.

VI. ISSUES

The issues involved in this Appeal are as follows:

A. Whether claims 4, 5, 9, 10, 14, 15 and 22 are unpatentable under 35 U.S.C. §103(a) over U.S. Patent No. 5,665,643 issued to Shin ("Shin") in view of U.S. Patent No. 5,243,221 issued to Ryan et al ("Ryan") and U.S. Patent No. 5,747,361 issued to Ouellet ("Ouellet").

B. Whether claims 6, 11, 16 and 19-21 are unpatentable under U.S.C. §103(a) over Shin in view of Ryan and Ouellet and in further view of U.S. Patent No. 5,635,763 issued to Inoue et al ("Inoue").

VII. GROUPING OF CLAIMS

All of the claims do not stand or fall together. Rather, Appellant contends that the claims can be divided into the following groups and each group is separately patentable:

Group I - Claims 4, 5, 9, 10, 14 and 15

Group II - Claim 6, 11, 21

Group III - Claims 16 and 19

Group IV - Claim 20

Group V - Claim 22

VIII. ARGUMENT

The Patent Office rejects claims 4, 5, 9, 10, 14, 15 and 22 as unpatentable under 35 U.S.C. §103(a) over Shin (U.S. Patent No. 5,665,643) in view of Ryan (U.S. Patent No.

5,243,221) and Ouellet (U.S. Patent No. 5,747,361), claims 6, 11, 16 and 19-21 over Shin, in view of Ryan and Ouellet, and in further view of Inoue (U.S. Patent No. 6,635,763).

A. **Overview of the Prior Art**

1. **Overview of Shin**

Shin teaches a method of manufacturing a semiconductor device having an insulating film which is formed by curing polysilazane that is coated on a substrate without corrosion or damage to the underlying wiring patterns. Shin, col. 2, lines 6-10. In an example of the process taught by Shin, a wiring pattern including a titanium layer, a titanium nitride layer, an aluminum-copper-titanium (AlCuTi) alloy layer and a silicon (Si) layer is used. Shin, col. 4, lines 17-24. This wiring pattern is covered with a SiON layer and then a polysilazane layer in a nitrogen (N_2) atmosphere that allows planarization without damaging or corroding the wiring layer. Shin, col. 4 lines 39 through col. 5 lines 13.

Shin does not teach an interconnect including an AlCuTi alloy that comprises less than 0.57 atomic percent titanium, or about 0.5 atomic percent copper. Further, Shin does not teach an Ti/TiN/AlCuTi alloy/Ti/TiN interconnect stack. Also, Shin does not teach an AlCuTi alloy interconnect that has a resistance in the range of 2.8 to 3.1 microOhm-cm.

2. **Overview of Ryan**

Ryan teaches doping aluminum used in the fabrication of silicon integrated circuits with iron. Ryan, col. 2, lines 3-4. The aluminum doped with up to 5 atomic percent iron substantially increases resistance to electromigration and creep. Ryan, col. 1, lines 17-19. In discussing prior attempts to avoid electromigration, Ryan teaches that either a titanium or copper dopant of up to 5 atomic percent is introduced into the aluminum. Ryan, col. 1, lines 58-61.

Ryan goes on to teach that prior interconnects including aluminum doped with titanium or copper were "unsatisfactory." Ryan, col. 1, lines 61-65. Use of the prior techniques according to Ryan does not solve problems of electromigration and creep and leaves the aluminum lines more susceptible to corrosion. Ryan, col. 1, lines 62-68. Further, Ryan does not teach an AlCuTi alloy

interconnect, a Ti/TiN/AlCuTi alloy/Ti/TiN interconnect stack, or an AlCuTi alloy interconnect with a resistance in the range of 2.8 to 3.1 micro Ohm-cm.

3. Overview of Oullet

Oullet teaches the formation of an interconnect layer and titanium based barrier layer. Oullet, col. 4, lines 46-53. The interconnect layer is saturated with titanium up to 1.25 percent by weight of the alloy and at least equal to the limit of solid solubility of titanium in aluminum at the temperature at which post treatment processing of the device occurs. Oullet col. 19, lines 18-24, col. 20, lines 16-20. Oullet teaches that the titanium nitride barrier layer is in direct contact with the upper surface of the interconnect layer. Oullet, col. 20, lines 14-20 and Figure 15. This combination of layers is designed to improve yield and reliability due to improvement in hillock, notch and spick reduction or elimination. Oullet, col. 20, lines 33-37.

Oullet does not teach an AlCuTi alloy with about 0.5 percent copper. Also, Oullet does not teach a Ti/TiN/AlCuTi alloy/Ti/TiN interconnect stack or an AlCuTi alloy with a resistance in the range of 2.8 to 3.1 micro Ohm-cm.

4. Overview of Inoue

Inoue teaches a semiconductor device with an insulating layer and an interconnect layer having a conducting layer. Inoue, Abstract. The interconnect layer of Inoue includes an aluminum alloy layer over titanium and titanium nitride layers and capped by a titanium and titanium nitride layer. Inoue, col. 4, lines 3-11. The aluminum alloy is one of aluminum-silicon-copper (AlSiCu), aluminum-copper (AlCu), aluminum-silicon (AlSi), aluminum-titanium (AlTi) or aluminum alloys that include one of magnesium, palladium, scandium and hafnium. Inoue, col. 5, lines 11-15.

Inoue does not teach an AlCuTi alloy that has about 0.5 atomic percent copper or 0.57 atomic percent titanium. Also, Inoue does not teach an AlCuTi alloy with a resistance in the range of 2.8 to 3.1 micro Ohm-cm.

B. Rejection of Group I Under 35 U.S.C. § 103(a) as Obvious over Shin in View of Ouellet and Ryan

In order to establish a *prima facie* case for obviousness it must be shown that the cited references teach or suggest each element of the claim. See *In Re* Reinhart, 189 U.S.P.Q. 143, 147 CCPA, 1976 ("'*prima facie'* case of obviousness is established where the teachings from the prior art itself would appear to have suggested the claimed subject matter"). Further, the Patent Office must show that there is some suggestion or motivation either in the references themselves or the knowledge generally available to one of ordinary skill in the art to combine the reference teachings. See *In Re* Vaeck, 20 USPQ2, 1438, 1442 (Fed. Cir. 1991), See also, MPEP § 2143.

In regard to claims 4, 9 and 14, these claims include the elements of an aluminum-copper titanium (AlCuTi) alloy layer which comprises less than 0.57 atomic percent titanium and about 0.5 atomic percent copper where the remainder is aluminum. The Patent Office relies on a combination of Shin, Ryan and Ouellet in order to teach each of these elements of these claims. Appellants believe that the Patent Office has failed to establish a *prima facie* case of obviousness because the cited references are improperly combined to teach the elements of claims 4, 9 and 14.

The Patent Office admits in Paper No. 19 that Shin does not teach an aluminum-copper-titanium alloy containing less than 0.57 atomic percent titanium and about 0.5 atomic percent copper. Instead, the Patent Office seeks to combine Ryan with Shin in order to teach 0.5 atomic percent of copper in an aluminum titanium copper alloy. However, in fact, Ryan teaches the use of a copper dopant of up to 5 atomic percent into aluminum in an attempt to avoid electromigration problems. However, Ryan states that the copper dopant is "unsatisfactory" as a solution because such high concentrations of copper make dry-etch pattern definition more difficult and lines more susceptible to corrosion. This results in problems related to creep and electromigration. See Ryan, Col. 1, lines 58-68. Ryan then teaches the use of an iron dopant in aluminum to reduce electromigration problems and creep.

See Ryan Col. 2, lines 3-10. Thus, Ryan teaches away from the use of a copper dopant in an aluminum alloy to improve electromigration and creep. Also, the description of prior art attempts at using a copper dopant do not teach the use of about 0.5 atomic percent copper in an aluminum titanium copper alloy. Rather, the section of Ryan that the Patent Office relies upon teaches an aluminum with only a copper dopant and the use of titanium as an alternative to a copper dopant. This section clearly states "a titanium or copper dopant at levels up to 5 atomic percent into the aluminum." Ryan, col. 1, lines 60 and 61. The term "or" in this context is clearly used as an "exclusive or" (i.e., either titanium or copper are used as a dopant). Therefore, one of ordinary skill in the art would not seek to combine the teachings of Ryan with the teachings of Shin because Ryan clearly teaches away from the use of a copper dopant in an aluminum alloy as a means for electromigration and creep. Therefore, the Patent Office has failed to establish that either Shin or Ryan suggest the desirability of an interconnect including an aluminum-copper-titanium alloy having about 0.5 atomic percent copper.

As noted above, the Patent Office admits in Paper No. 19 that Shin does not teach or suggest an aluminum-copper-titanium alloy that includes less than 0.5 atomic percent titanium. The Patent Office relies on Ouellet to correct this defect of Shin. However, the Patent Office has not identified and the Appellants have been unable to discern any part of Ouellet that teaches or suggests an aluminum-copper-titanium alloy containing less than 0.57 atomic percent titanium and where the remainder of the alloy is aluminum. Rather, the Patent Office has identified sections of Ouellet that teach the use of an aluminum-silicon-copper or an aluminum-titanium alloy. See Ouellet, col. 19, lines 18-50. Thus, the Patent Office has failed to identify and Appellants have been unable to discern any part of Ouellet that teaches an aluminum-copper-titanium alloy having less than 0.5 atomic percent titanium, 0.5 atomic percent copper and where aluminum is the remainder of the alloy. Thus, Shin cannot be combined with Ryan, and Shin and Ouellet combined do not teach each of the elements of claims 4, 9 and 14. Therefore, the Patent Office has failed to establish a *prima facie* case of obviousness for claims 4, 9 and 14.

In regard to claims 5, 10 and 15, these claims depend from independent claims 4, 9 and 14 and incorporate the limitations thereof. Thus, at least for the reasons mentioned in regard to 4, 9 and 14, these claims are not obvious over Shin in view of Ryan and Ouellet. Accordingly, it is requested that the obviousness rejection of claims 4, 5, 9, 10, 14 and 15 be overturned.

C. Rejection of Group II Under 35 U.S.C. § 103(a) as Obvious over Shin in View of Ryan and Ouellet and Further in View of Inoue

In regard to claims 6, 11 and 21, these claims include the elements of an aluminum-copper-titanium alloy layer comprising less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder being aluminum. Thus, for the reasons mentioned in regard to Group I, these claims are not obvious over Shin in view of Ryan and Ouellet. Further, Inoue does not teach an aluminum-copper-titanium alloy having 0.5 atomic percent copper and less than 0.57 atomic percent titanium and thus does not cure the defects of Shin, Ryan and Ouellet. Thus, the cited references cannot be combined to teach or suggest each of the elements of claims 6, 11 and 21.

In addition, these claims include the elements of an interconnect stack where a titanium layer is overlaid by a titanium nitride layer which is overlayed by an aluminum-copper-titanium alloyed layer which is overlayed by a titanium layer with is overlayed by a titanium nitride layer (Ti/TiN/AlCuTi/Ti/TiN). The Patent Office admits in Paper No. 19 that Shin does not teach this layered structure. The Patent Office has not indicated and Appellants have been unable to discern any part of Ryan or Ouellet that teaches such a structure. Instead, the Patent Office relies on Inoue for teaching the interconnect stack structure as claimed in claim 6, 11, and 21. However, Ouellet teaches away from the use of a titanium layer overlaying an aluminum alloy layer. Ouellet clearly teaches a titanium nitride barrier layer over the aluminum alloy that prevents the formation of spikes, hillocks and notches in the aluminum alloy interconnect. See Ouellet, col. 20, lines 13-20. In fact, Ouellet teaches away from the use of a pure titanium layer over the aluminum alloy. Ouellet teaches that use of a pure titanium layer over the aluminum alloy would result in the penetration of and the chemical attack of the aluminum alloy by the titanium layer to form $TiAl_3$.

See Ouellet, col. 12, lines 31-34. Thus, Ouellet expressly teaches away from the layering of titanium over the aluminum alloy layer and thus one of ordinary skill in the art would not think to combine the teachings of Ouellet, upon which the Patent Office relies for teaching an aluminum-copper-titanium alloy with less than 0.57 percent titanium, with the stack structure of Inoue. Therefore, Ouellet cannot be combined with Inoue, and thus Ryan, Ouellet and Inoue cannot be combined in order to teach each of the elements of claims 6, 11 and 21. These claims are separately patentable because the cited references cannot be combined to teach the additional elements of the claims of Group II. Accordingly, the obviousness rejection of claims 6, 11 and 21 are requested to be overturned.

D. Rejection of Group III Under 35 U.S.C. § 103(a) as Obvious over Shin in View of Ryan, Ouellet and Inoue

Claim 16 includes many of the same elements as independent claim 4 including aluminum-copper-titanium alloy layer wherein the aluminum-copper-titanium alloy layer comprises less than 0.57 atomic percent titanium in about 0.5 atomic percent copper where the remainder is aluminum. Thus, for the reasons mentioned in regard to Group I, claim 16 is not obvious over Shin in view of Ryan and Ouellet. Further, as mentioned in regard to Group II, Inoue does not teach or suggest aluminum-copper-titanium alloy layer having less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder being aluminum. Therefore, Shin cannot be combined with Ryan, Ouellet and Inoue to teach or suggest each of the elements of claim 16.

In regard to claims 19 and 20, these claims depend from independent claim 16 and incorporate the limitations thereof. Thus, at least for the reasons mentioned in regard to claim 16, Shin cannot be combined with Ryan, Ouelett, Inoue to teach each of the elements of these claims. Claims 16, 19 and 20 have a separate ground for rejection from the claims of Group I. Accordingly, it is requested that the obviousness rejection of claim 16, 19 and 20 be overturned.

E. <u>Rejection of Group IV Under 35 U.S.C. § 103(a) as Obvious over Shin in View of Ryan, Ouellet and Inoue</u>

In regard to claim 20, this claim depends from independent claim 16 and incorporates the limitations thereof. Thus, at least for the reasons mentioned in regard to Group III, <u>Shin</u> cannot be combined with <u>Ryan</u>, <u>Ouellet</u> and <u>Inoue</u> to teach or suggest each of the elements of claim 20.

In addition, claim 20 include the elements of an aluminum-copper-titanium alloy layer which comprises about 0.5 atomic percent copper and about 0.1 atomic percent titanium. The Patent Office has not identified and Appellants have been unable to discern any part of <u>Shin</u>, <u>Ryan</u>, <u>Ouellet</u> or <u>Inoue</u> that teaches or suggests aluminum-copper-titanium alloy having the claimed ratio of aluminum, copper, and titanium. As discussed above in regard to Group I and II, <u>Shin</u> and <u>Inoue</u> do not teach an aluminum-copper-titanium alloy for an interconnect stack structure having about 0.5 atomic percent copper and less than 0.57 atomic percent titanium. Instead, the Patent Office relies on <u>Ryan</u> to teach the use of about 0.5 atomic percent copper and <u>Ouellet</u> to teach less than 0.57 atomic percent titanium. Thus, none of the cited references teach an aluminum-copper-titanium alloy having a ratio of copper to titanium as claimed. Further, the Patent Office has not established any motivation to combine the references to teach an aluminum-copper-titanium alloy having about 0.5 atomic percent copper and about 0.1 atomic percent titanium. The Patent Office has failed to establish the prior art teaches the desirability of the claimed invention in relation to claim 20. See *In Re* Rouffet, 47 USPQ2d 1453, 1457-58 (Fed. Cir. 1998) (Finding the combination of the references taught every element of the claimed invention, however without a motivation to combine, the rejection based on a prima facie case of obviousness was held in improper); See Also MPEP § 2143.01. Thus, <u>Shin</u> cannot be combined with <u>Ryan</u>, <u>Ouellet</u> and <u>Inoue</u> to teach or suggest each of the elements of claim 20. Claim 20 is separately patentable because it includes additional elements not taught by the cited references. Accordingly, Appellants respectfully request that the obviousness rejection of claim 20 be overturned.

F. Rejection of Group V Under 35 U.S.C. § 103(a) over Shin, Ryan and Ouellet

Claim 22 depends from independent claim 4 and incorporates the limitations thereof. Thus, at least for the reasons mentioned in regard to Group I, Shin cannot be combined with Ryan and Ouellet to teach each of the elements of claim 22.

In addition, claim 22 includes the elements of an aluminum-copper-titanium alloy having resistance in the range of 2.8 to 3.1 micro Ohm-cm. The Patent Office states in Paper No. 19 that it is inherent to the interconnect of the combined references that it have a resistance in the claimed range. However, as discussed in regard to Group IV, the Patent Office has not established that Shin can be combined with Ryan and Ouellet to teach an aluminum-copper-titanium alloy layer with about 0.5 atomic percent copper and about 0.1 atomic percent titanium. This specific combination of copper and titanium in an aluminum alloy has an unexpected result of having a lower resistivity than would be expected. One of ordinary skill in the art would expect an aluminum-copper-titanium alloy with these percentages of copper and titanium to have a resistivity of about 3.5 micro Ohm-cm. Copper has a residual resistivity in aluminum of about 0.81 micro Ohm-cm at.%. Thus, one of ordinary skill in the art would expect that the maximum solubility of titanium in pure aluminum would result in a higher resistivity than observed in the aluminum copper alloys. In this case, the expected resistivity would be about 3.5 micro Ohm-cm for an AlCuTi alloy. However, actual measurement of the resistivity of the aluminum-copper-titanium alloy having about 0.5 percent copper and about 0.1 percent titanium produced a resistivity in the range of 2.8 to 3.1 micro Ohm-cm. Therefore, the aluminum alloy as claimed is not obvious over Shin in view of Ryan and Ouellet. Inoue does not cure the defects of Shin, Ryan and Ouellet as discussed in regard to Group III. The Patent Office has not indicated any part of Inoue that teaches or suggests an aluminum-copper-titanium alloy as claimed in claim 4. Therefore, Shin in view of Ryan, Ouellet and Inoue does not teach or suggest each of the elements of claim 22. Claim 22 is separately patentable because it includes additional elements not taught by the cited references.

Accordingly, Appellants respectfully request that the obviousness rejection of claim 22 be overturned.

IX. CONCLUSION AND RELIEF

Accordingly, it is submitted that the rejections of claims 4-6, 9-11, 14-16 and 19-22 based on 35 U.S.C. §103 be overturned.

Respectfully submitted,

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

Dated: 2/25/03 By: William V Babbitt

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CERTIFICATE OF MAILING:

I hereby certify that this correspondence is being deposited as First Class Mail, with the United States Postal Service in an envelope with sufficient postage addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on February 25, 2003.

Lillian E. Rodriguez 2-25-03

Lillian E. Rodriguez February 25, 2003

X. APPENDIX

The claims involved in this Appeal are as follows:

4. An interconnection comprising:

an aluminum copper titanium alloy layer, wherein the aluminum-copper-titanium alloy layer comprises less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder is aluminum.

5. The interconnection of claim 4, wherein the aluminum-copper-titanium alloy layer comprises about 0.1 atomic percent titanium.

6. The interconnection of claim 4, further comprising:

a first titanium layer;

a first titanium-nitride layer;

a second titanium layer; and

a second titanium-nitride layer,

wherein the second titanium-nitride layer overlies the second titanium layer, the aluminum-copper-titanium alloy layer overlies the second titanium-nitride layer, the first titanium layer overlies the aluminum-copper-titanium alloy layer, and the first titanium-nitride layer overlies the first titanium layer.

9. An interconnection formed on a substrate of an integrated circuit comprising an aluminum-copper-titanium alloy layer, wherein the aluminum-copper-titanium alloy layer comprises less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder is aluminum.

10. The interconnection of claim 9, wherein the aluminum-copper-titanium alloy layer contains about 0.1 atomic percent titanium.

11. The interconnection of claim 10, further comprising:

a first titanium layer;

a first titanium-nitride layer;

a second titanium layer; and

a second titanium-nitride layer,

wherein the second titanium-nitride layer overlies the second titanium layer, the aluminum-copper-titanium alloy layer overlies the second titanium-nitride layer, the first titanium layer overlies the aluminum-copper-titanium alloy layer, and the first titanium-nitride layer overlies the first titanium layer.

14. An integrated circuit comprising:

a substrate; and

an interconnection level disposed about the substrate, the interconnection level having an aluminum-copper-titanium alloy layer, wherein the aluminum-copper-titanium alloy layer comprises less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder is aluminum.

15. The integrated circuit of claim 14, wherein the aluminum-copper-titanium alloy layer contains about 0.1 atomic percent titanium.

16. A multilayered interconnection structure formed on a substrate, the interconnection comprising:

a first titanium layer;

a first titanium nitride layer;

an aluminum-copper-titanium alloy layer, wherein the aluminum-copper-titanium alloy layer comprises less than 0.57 atomic percent titanium, about 0.5 atomic percent copper and the remainder is aluminum;

a second titanium layer; and

a second titanium nitride layer.

19. The multilayer structure of claim 16, wherein the aluminum-copper-titanium alloy layer contains 0.1 atomic percent titanium.

20. The multilayered structure of claim 16, wherein the aluminum-copper-titanium alloy layer comprises about 0.5 atomic percent copper and about 0.1 atomic percent titanium.

21. The multilayer structure of claim 16, wherein the second titanium-nitride layer overlies the second titanium layer, the aluminum-copper-titanium alloy layer overlies the second

titanium-nitride layer, the first titanium layer overlies the aluminum-copper-titanium alloy layer, and the first titanium-nitride layer overlies the first titanium layer.

22. The interconnect of claim 4, wherein the aluminum-copper-titanium alloy has a resistance in the range of 2.8 to 3.1 micro Ohm-cm.